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ABSTRACT

Successfully retrofitting aging K-12 schools using energy conservation measures (ECM) that can improve the physical plant and reduce energy consumption are explored. Topics explore how certain ECM measures can benefit educational facilities, why retrofitting begun sooner rather than later is important, how to finance the retrofit program, and the phases retrofit programs have in common. Contracting strategies for school districts that choose not to use Energy Savings Companies (companies providing design, construction, and financing with a guaranteed construction cost and energy savings component) are also examined, as well as the pros and cons of both strategies. (GR)

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ED 434 483

a 3D/International essay

ENERGY RETROFIT FOR AGING K-12 SCHOOLS

There are few opportunities to save money and improve facilities at the same time. Yet successful energy programs do just that. An energy retrofit program may be a rare opportunity for school districts whose facilities have older and less efficient heating, ventilating and air conditioning (HVAC) systems; lighting; or building enclosure systems.

Upgrading lamps and ballasts give better lighting. Upgrading HVAC control systems helps maintain a more constant temperature. New walls or roofs improve esthetics and prevent air leakage. All of these will save money and provide a better learning environment.

Each of the Energy Conservation Measures, called ECMs, improves the physical plant and reduces energy consumption. The money saved can be directed back to make further improvements in facilities or programs.

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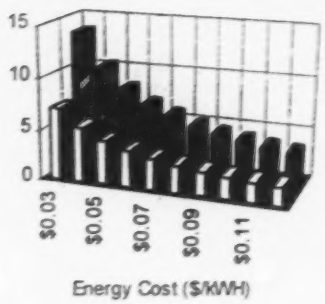
Is there an opportunity?

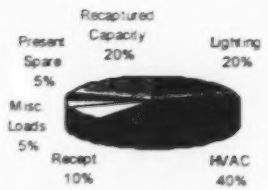
The first question is whether or not facilities will benefit from energy retrofit. Here are some broad guidelines for Energy Conservation Measures in lighting, HVAC and thermal enclosures:



Lighting ECMs Chances are that up to 50 percent of lighting energy can be saved if lighting was installed during the 1970s or earlier.

In 1968 it took approximately 2.4 watts/s.f. to produce 50 footcandles of light at desk level. Today that same light level can be produced with 1.1 watts/s.f. At six cents per kWH, it's possible to pay for improved lighting in three to four years.

Many older schools need to expand electrical distribution capacity to accommodate increased technology equipment and advanced instructional aids. Normally, lighting retrofit energy savings reflect a 20 percent reduction in overall energy dollars spent. This represents a substantial amount of buying power for upgrading facilities or expanding curriculum. This 20 percent reduction in energy use also correlates to 20 percent recaptured capacity in the school's electrical distribution equipment and cabling systems—capacity which can be efficiently and economically put to use. Lighting retrofits may be the best way for gaining that capacity providing a dual reward from both energy savings and distribution flexibility.



Through lighting retrofit, 20% of the building's existing electrical distribution capacity can be made available for powering new technology or advanced instructional aids

Heating, ventilating and air conditioning ECMs Newer heating, ventilating and air conditioning (HVAC) systems cost less to operate. Compressors and heat exchangers are more efficient. Their related control systems have become more sophisticated and make it possible to balance room temperatures more evenly, saving money and providing more comfort.

The viability of retrofit programs for HVAC equipment is directly dependent upon the age of the equipment. Increased equipment efficiency ratings and their ability to save energy makes equipment near the end of its expected a good target for energy programs. Three factors affect HVAC upgrades as viable ECMs:

1. How long will it be before equipment is scheduled for replacement under the district's maintenance plan?
2. What are the efficiency ratings of existing units?
3. What is the availability of parts for appropriate preventative or operational maintenance?

Although replacement of HVAC systems under an energy retrofit program may not have the most economical payback periods, the availability to future budgeted funds or budget savings from reduced maintenance expenses could make an upgrade financially attractive.

Thermal enclosure ECMs The walls and roofs that enclose space are referred to as the thermal enclosure. They all radiate and transfer heat and they leak air.

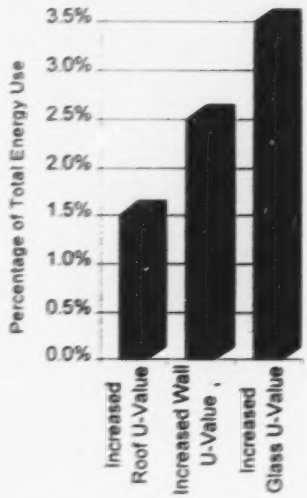
They may also have a substantial effect on comfort. A child sitting next to a cold pane of glass will radiate heat to that glass and be uncomfortable no matter what the ambient room air temperature is.

Insulation, reflective coatings for glass, and sealants (caulking) have steadily improved over the last three decades. The relative cost of double glazing has dropped. Window and door frames are tighter. Better insulation, air tight construction, better caulking, reflective glass and double glazing save energy and increase comfort levels.

An existing structure may be a candidate for thermal envelope energy savings if:

- the roof, wall or glazing U-Values are greater than or equal to 0.06
- the glazing shading coefficient is greater than or equal to 0.90

If school administrators believe that benefits from ECMs may exist, the next step is to call in an engineer who understands energy retrofit programs. An engineer can quickly model for energy and maintenance life cycle savings and give an educated opinion on the probability and magnitude of retrofit benefits.



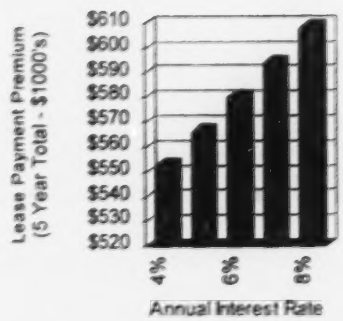
Optimizing the opportunity

Low interest There are good reasons to begin a retrofit program sooner rather than later. As of this writing, interest rates are historically low. If they go up, potential savings will be lost. The graph below shows the substantial capital lost if programs do not take advantage of these low rates.

The program modeled assumes payment on a five-year lease for a $500,000 retrofit project with a four percent APR. Each increase of one percent resulted in the total interest payment on the lease increasing by 26 percent, a value of approximately $56,000 if rates increase from four to eight percent. This equates to considerable lost opportunities.

Deregulation The electrical utility industry is being deregulated. Historically, deregulation has lowered costs. Most economists predict that energy costs will drop during the next decade. Simple mathematics shows, if energy costs drop by 33 percent due to deregulation, pay-back periods will be three times longer. Of course, school districts will be delighted with lower energy costs but energy retrofit savings will be reduced and retrofit programs will not be as financially attractive. Acting today allows for funds within present budget allocations to provide additional physical plant and operational benefit immediately.

Administrators of existing retrofit programs will have to act to assure that operational savings caused by deregulation are appropriately reallocated. Programs with long payback periods could quickly become financial failures if planned for funds are not made available.



Above is a graph of the amount of dollars required to payback a $500,000, 5 year lease program at varying annual interest rates

Mixing short-term and long-term projects Retrofit programs are not only a matter of engineering and economics. A retrofit program allows districts to improve some facilities for functional rather than economic reasons. Administrators can mix upgrades with both long-term and short-term payback periods—or with improvements that have no payback at all. For instance, wall and roof insulation upgrades may have a five to seven year payback, but when implemented with required roof maintenance, the payback may require ten years.

Particularly when HVAC system ECMs are considered, engineering can become more art than science. The way people use facilities make heating and air-conditioning performance hard to predict. One example is control system upgrades. The way people use the controls will affect energy consumption. And although energy savings may be difficult to calculate, the opportunity for district-wide standardization, flexibility and maintenance knowledge would provide long-term economies.

FINANCING THE PROGRAM

After school administrators determine that their districts would likely benefit from energy retrofit, they have to decide how to finance the program. This decision will influence all the other downstream decisions. There are two approaches that school districts take:

1. They contract with an Energy Savings Company (ESCO) that will provide financing.
2. They finance the retrofit themselves. Funds may be raised through a bond issue or through a tax exempt lease or loan with a private agency specializing in public institutional debt. An ESCO is able to acquire financing based on the energy savings it can achieve. A school district can do the same. (See our essay on lease/purchase of schools.)

Energy Savings Company (ESCO) An ESCO company provides design, construction and finance with a guaranteed construction cost and guaranteed energy savings. The relationship begins with the initial facility survey and usually must include an extended equipment maintenance service contract through the pay-back period.

Pros The principal advantage of an ESCO is that the district does not have to arrange financing and has a guaranteed financial result. However, the potential savings to a district are less with an ESCO for several reasons:

1. The ESCO approach has built-in costs that a self-funded approach does not. In order to pay a percentage of the savings to the ESCO, one must know what the savings are. That means that the ESCO and the district must determine a baseline rate energy consumption cost and then set up systems to monitor the new consumption after the retrofit. The ESCO must also make sure that the district doesn't add energy consuming activities not included in the baseline case. If the district does add, or subtract, they must negotiate the difference and adjust the baseline. An extra football game at home, a new program that uses the auditorium, or a new computer lab may require a negotiation. Also, the labor cost of monitoring energy usage and the necessary equipment to do so must come out of savings.
2. The ESCO may identify and possibly insist upon incorporating inappropriate ECMs to help attain cost savings.
3. Districts are usually able to secure lower interest rates than an ESCO.
4. An ESCO may carry insurance against losses on unachieved savings. These costs are passed on through program fees, again increasing costs.

5. The ESCO will require commitment to its own extended service contract, eliminating the district's ability to take competitive pricing.

Because of these many financial disadvantages, ESCO programs are being closely scrutinized and are becoming uncommon in the private sector.

Self-funding If a school district finances a retrofit program themselves, they have the potential to lower the initial capital costs through greater competition, eliminate the cost of monitoring, lower interest costs, eliminate negotiations when there is a change in facility use and maintain competition for maintenance contracts. However they must manage the effort, or retain someone who will. And since there is no up-front guarantee, they must retain reliable professionals to manage and engineer the program.

THE PROCESS

All energy retrofit programs have distinct phases in common:

1. Feasibility and financial analysis
2. Detailed engineering and contract documents
3. Implementation

An ESCO will have the additional phase of monitoring, maintenance and service.

Feasibility and financial analysis The first step is to determine how much the district can save. To do this, energy engineers divide targets of opportunity into categories. Each category has a construction cost, an energy savings and a payback period associated with it.

The engineers then survey the facilities and develop spreadsheets that identify lighting retrofit opportunities. They will likely use a database of lighting ECMs cataloging implementation costs, energy consumption, energy savings and rebate opportunities. They will use life cycle cost analysis software, such as the Trane Company's "System Analyzer", to model ECMs affecting building mechanical systems—for instance, glazing and insulation upgrades or heat recovery systems.

The feasibility report summarizes the cost and the savings. Cost includes, design, management, construction, insurance and monitoring. A financial analysis includes the anticipated energy savings and retrofit costs with a cash flow and return on investment calculation. Payments for lease/loan programs are calculated and compared to an anticipated savings in energy, maintenance, operations and utility rebates.

Detailed engineering and contract documents After confirming financial arrangements, the energy engineer completes the design detailing. Depending upon the implementation contracting approach (ESCO or self-funding) performance or detailed construction documents and specifications for the energy conservation measures are developed. Lighting fixture replacements are described, lamp/ballast upgrades are defined, and lense/louver replacement or cleaning is detailed. Equipment schedules are provided with associated one-line diagrams depicting mechanical equipment or systems modifications and upgrades. Associated architectural revisions are also detailed for all typical applications.

Implementation This is the actual construction or renovation phase of the project. All the work described in the construction documents and specifications is put into place.

Scheduling is important during the construction phase of any school district retrofit project. With most construction to be completed over summer break, scheduling for restrictive access and time-frame conditions is critical. Several school district facilities, such as the administrative and maintenance buildings, remain active during the summer and require work to occur only after hours or on weekends. Staff must be available at all times so that field condition problems can be addressed as they are encountered. The construction phase requires a partnering and team approach among the school administration, engineers, construction administrator and the contractors to assure a successful project.

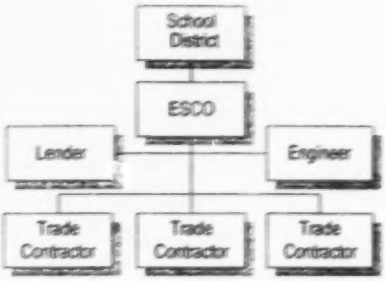
Exactly how the construction is accomplished has been determined earlier by the choice of contracting strategies.

Contracting Strategies

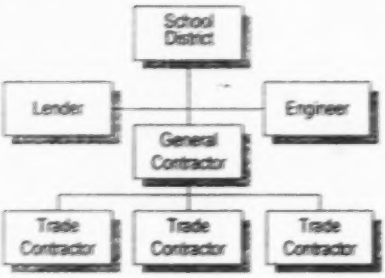
If the school district has chosen to fund independently, rejecting the ESCO option, there are contracting strategies to be considered. The typical choices are basically the same as for any construction project.

- Traditional Process (Design, Bid, Construct)
- Engineering and Construction Management

There are variations on each of these processes. The choice depends on the conditions and circumstances of the individual school district and its community.



Traditional design/bid/construct Design/bid/construct contracting is the delivery process most used by school districts. The program during design is led by an engineering consultant who is contractually obligated to work in the best interest of the owner to meet programming needs. Construction documents are produced and bid, and the project is constructed under a general contractor agreement with the lowest responsible bidder.



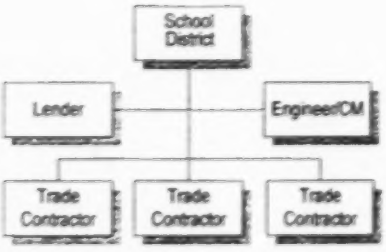
Contracting Pros:

- Design and construction contracts can be separated to allow for increased community business involvement.
- Design phase is led by a consultant with a fiduciary responsibility to work in the best interest of the district.
- The district maintains complete control of design quality.

Contracting Cons:

- General Contractor has control of sub-contractors and construction program schedule, not the district.
- Entire contract is awarded to lowest bidder, increasing chance of cost disputes.

Engineering and construction management Engineering and construction management (CM) is a professional service using a team of design and construction personnel responsible for the program from survey through commissioning. The program has a single point of contact and responsibility with the Engineer/CM to assure the district that a complete and coordinated program is delivered and that the district personnel are satisfied with and trained on the systems delivered.



During the design phase, professional engineers are used to develop an integrated system approach to energy conservation measures considered and implemented.

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The documents and specifications prepared for each facility are packaged to meet the needs of the project. The work is bid directly to the trade contractors. The Engineer/CM replaces the General Contractor. The make-up of each bid would vary depending on combined estimated construction cost, school mix—high school, middle school, elementary school—or geographic relationship. Packaging bids in this manner allows for increased access to subcontractors for greater local participation and increased involvement by small, minority or women-owned businesses.

The construction management staff use trade contracting to control bid and construction costs and provide the district with an "open book" accounting of all implementation costs.

Pros

- All of the Pros of Traditional Design/Bid/Construct apply to this contracting strategy.
- Design phase and construction phase is led by a consultant team with a fiduciary responsibility to work in the best interest of the district.
- Use of the construction manager as bid coordinator and administrator allows for flexible trade packaging, increasing local contractor community involvement and expanding women and/or minority contractor involvement.
- The district maintains complete control of design and construction quality.
- The CM, as the district's agent, has control of the trade contractors during the construction phase and the overall program schedule.
- It allows for use of design-build approach, giving the contractor flexibility in pricing and enabling adaptation to field conditions to minimize change orders.
- It saves Money!

Cons:

- As in the traditional process, the contract is awarded to lowest bidder. Although this may increase the chance of cost disputes, trade contracting does allow for greater control and ease in replacement of non-performing contractors.

3D/I QUALIFICATIONS

National organization 3D/I was established in 1953 as a design and management firm. We are organized around 4 disciplines—construction management, engineering, architecture and environmental services. Our scope of work ranges from the design and management of the Fremont Unified School District's lighting retrofit (part of a $90 million bond program) to the construction management on the State of California State Archives Building and Secretary of State offices. 3D/I specializes in public sector design and construction management projects. Our work for public agencies exceeds $7 billion of construction in the last three years.

3D/I provides energy conservation and retrofit services for clients throughout the U.S. Our integrated services approach allows us to provide construction management, architecture, engineering and environmental services to a district on any area affected by their energy retrofit program.

Schools We have worked on over 400 school projects throughout the U.S. and have helped other government clients think through their approach to private financing. We have developed relationships with several financing institutions that are interested in backing energy-related projects using our program. School construction is a market specialty for 3D/I. In our Western Region, 75 percent of our work is K-12 school projects. Over the past 10 years, we have managed and/or designed over one billion dollars in school construction projects.

Services 3D/I uses an open-ended, flexible approach to deliver our services. We tailor to our client's needs. Our services include:

- Project/Construction Management
- Facilities Audits and Assessments
- Energy Audits and Retrofits
- Asset Analysis
- Engineering
- Value Engineering
- Maintenance Planning
- Master Planning
- Scheduling and Estimating
- Locating Financing Options
- Design-Build Contracting
- Constructibility Review
- Strategic Facility Planning
- Claims Avoidance & Resolution
- Urban Design
- Change Order Negotiation
- Indoor Air Quality
- Risk Assessment

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